

COMBINING SOFT COMPUTING AND PARALLEL PROCESSING FOR THE OPTIMUM DESIGN OF LARGE-SCALE STRUCTURES

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The optimum design of large-scale structures, such as multi-storey 3D frames or space trusses modeled with several thousands degrees of freedom (d.o.f.), is a computationally intensive task. When evolutionary algorithms are applied for this purpose, the solution of the Finite Element (FE) equilibrium equations is of paramount importance and requires the use of efficient computational techniques, in order to accelerate the overall optimization process and make it more tractable in practice [1,2].

In the present study a structural optimization methodology based on Evolution Strategies (ES) is efficiently applied on sequential and parallel computing environments. In evolutionary design optimization successive linear systems with multiple left-hand sides have to be processed, since the stiffness matrix of the structure changes in every newly examined design. The techniques implemented in this work accelerate the FE solutions by taking advantage of the fact that the stiffness matrices of successively defined designs have relatively small differences. The implemented iterative solution methods, which are properly adjusted to the special characteristics of the ES process, are based on the Preconditioned Conjugate Gradient (PCG) algorithm [1] and on the method of Finite Element Tearing and Interconnecting (FETI) [3]. Two alternative parallel implementations are investigated: (i) the natural parallelization of the ES procedure by performing independent complete FE analyses in each processor and (ii) the partitioning of the global FE problem into subdomains and the treatment of each optimization step with domain decomposition methods, which can handle the substructures assigned to each processor.

Neural Networks (NN) belong to the soft computing techniques simulating the human brain functions. The use of artificial intelligence techniques, such as neural networks, to predict FE analysis outputs has been previously studied in the context of optimal design of structural systems. In the present work a NN-based approach is employed, which improves its prediction capabilities during the ES process, thus enhancing the overall performance of the optimization procedure.

The proposed algorithms, which combine the *effectiveness* provided by soft computing and the *efficiency* gained through parallel processing, are executed on ethernet-networked PCs using the Linux operating system and the message passing library PVM. The developed software allows the optimum design of two- and three-dimensional skeletal structures with several thousands d.o.f. in realistic computing times.

References

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